PICO
THE RISE OF MICROCONTROLLER
RUBY

EPISODE Ⅳ

@hasumikin

RubyConf Taiwan 2023

Dec. 15, 2023

Arts-Wallpapers.com

Find PicoRuby's history on the internet

EPISODE Ⅱ

ATTACK OF THE RAKE

EPISODE Ⅲ

REVENGE OF THE STDIN

Extra edition in Euruko 2023

"A Beginner's Complete Guide"

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self.inspect

- Hitoshi HASUMI
- hasumikin (GitHub ,ex-Twitter, Bluesky and Mastodon)
- Creator of PicoRuby and PRK Firmware
- Committer of CRuby's IRB and Reline
- First prize of Fukuoka Ruby Award (2020 and 2022✌️)
- A final nominee of Ruby Prize 2021

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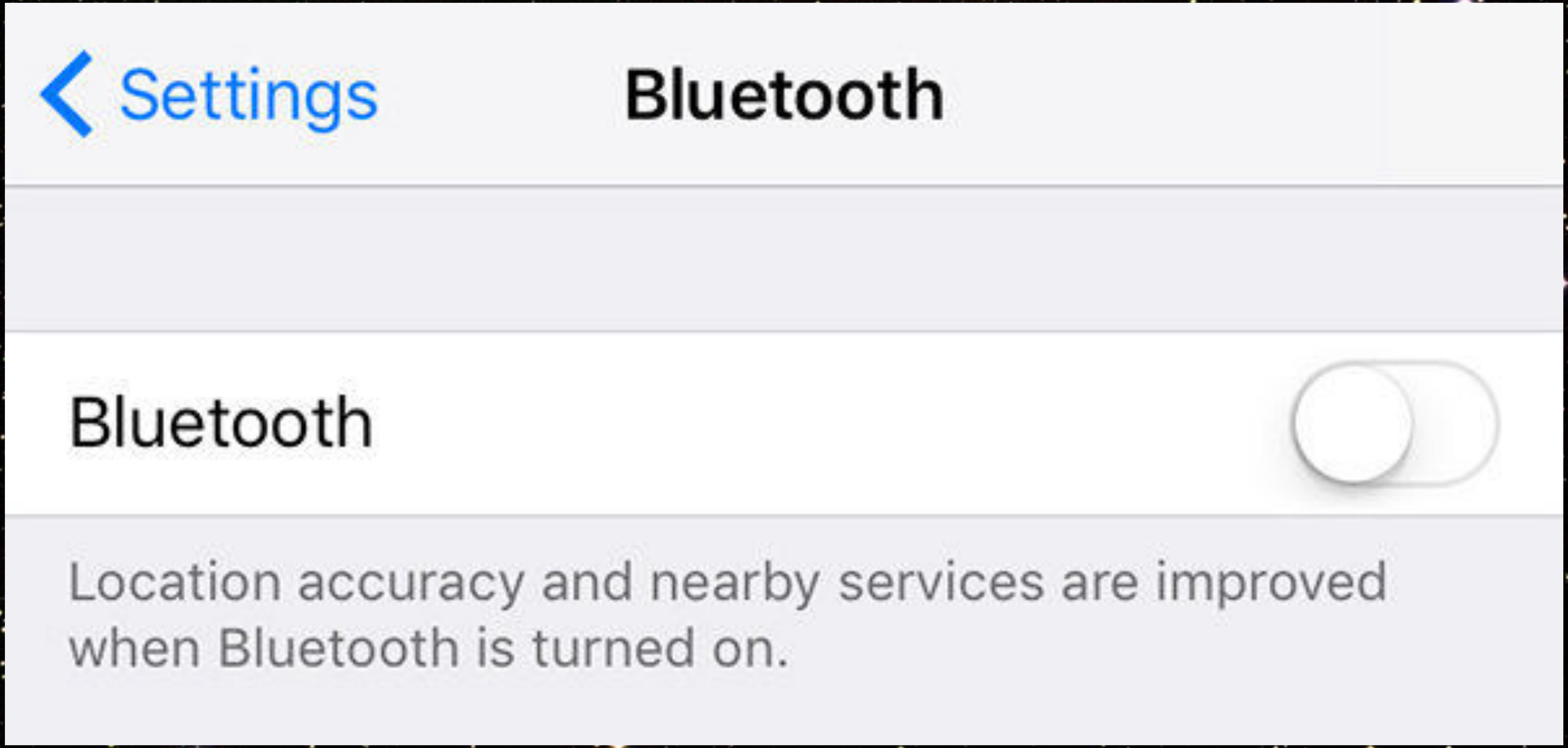
I have a favor to ask

If possible, please turn off your Bluetooth



Bluetooth

Location accuracy and nearby services are improved when Bluetooth is turned on.

To avoid channel congestion during my talk

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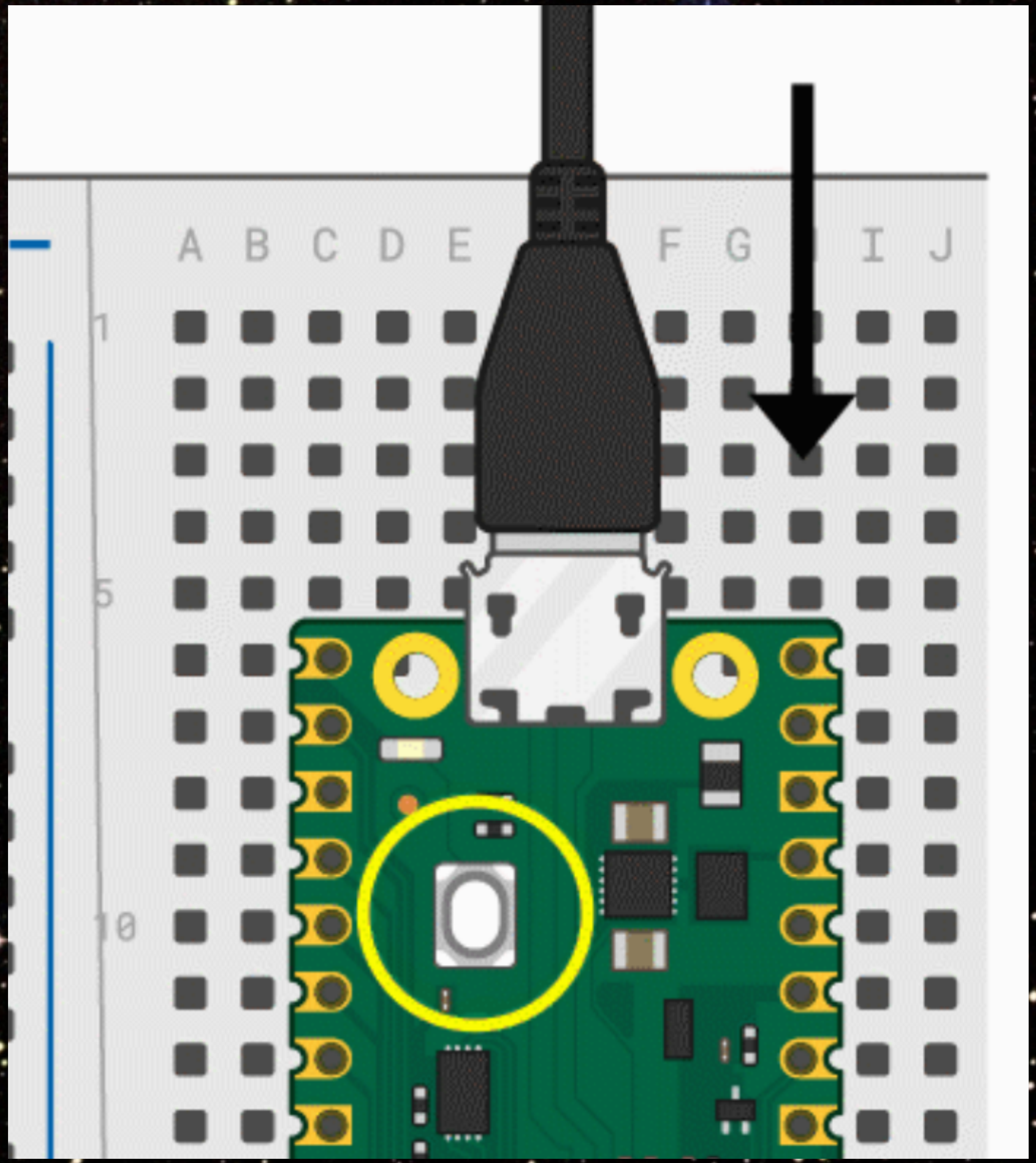
Let's begin 1/5

- Connect Pi Pico and PC while pressing the BOOTSEL button
  - You'll find "RPI-RP2" drive in file manager



https://www.raspberrypi.org/documentation/rp2040/getting-started

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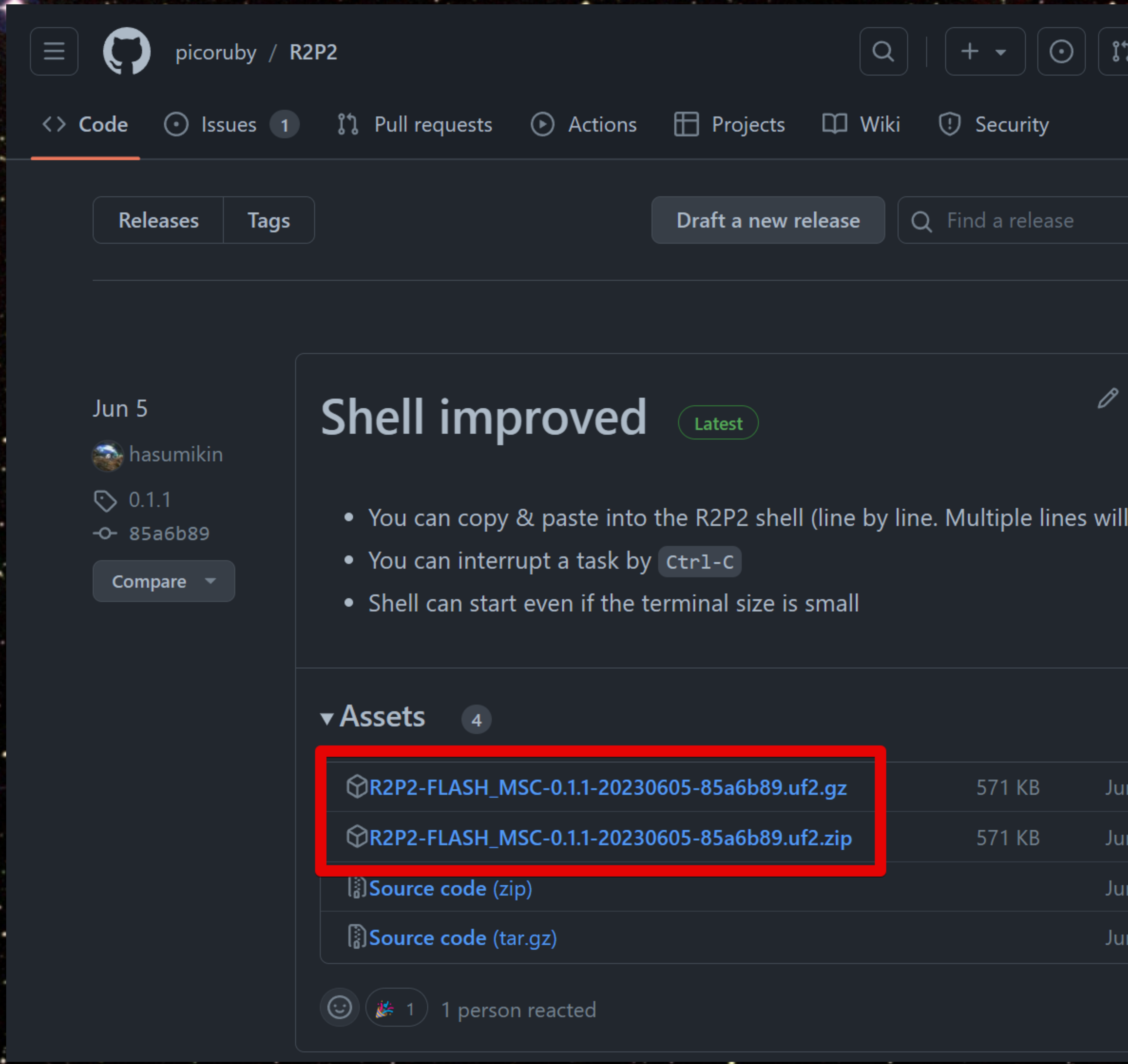
Let's begin 2/5

- Download the latest `R2P2-*.uf2` from GitHub

https://github.com/picoruby/R2P2/releases



Jun 5
hasumikin
0.1.1
85a6b89

Shell improved Latest

- You can copy & paste into the R2P2 shell (line by line. Multiple lines will
- You can interrupt a task by `Ctrl-C`
- Shell can start even if the terminal size is small

Assets 4

R2P2-FLASH_MSC-0.1.1-20230605-85a6b89.uf2.gz	571 KB	Ju
R2P2-FLASH_MSC-0.1.1-20230605-85a6b89.uf2.zip	571 KB	Ju
Source code (zip)		Ju
Source code (tar.gz)		Ju

1 1 person reacted

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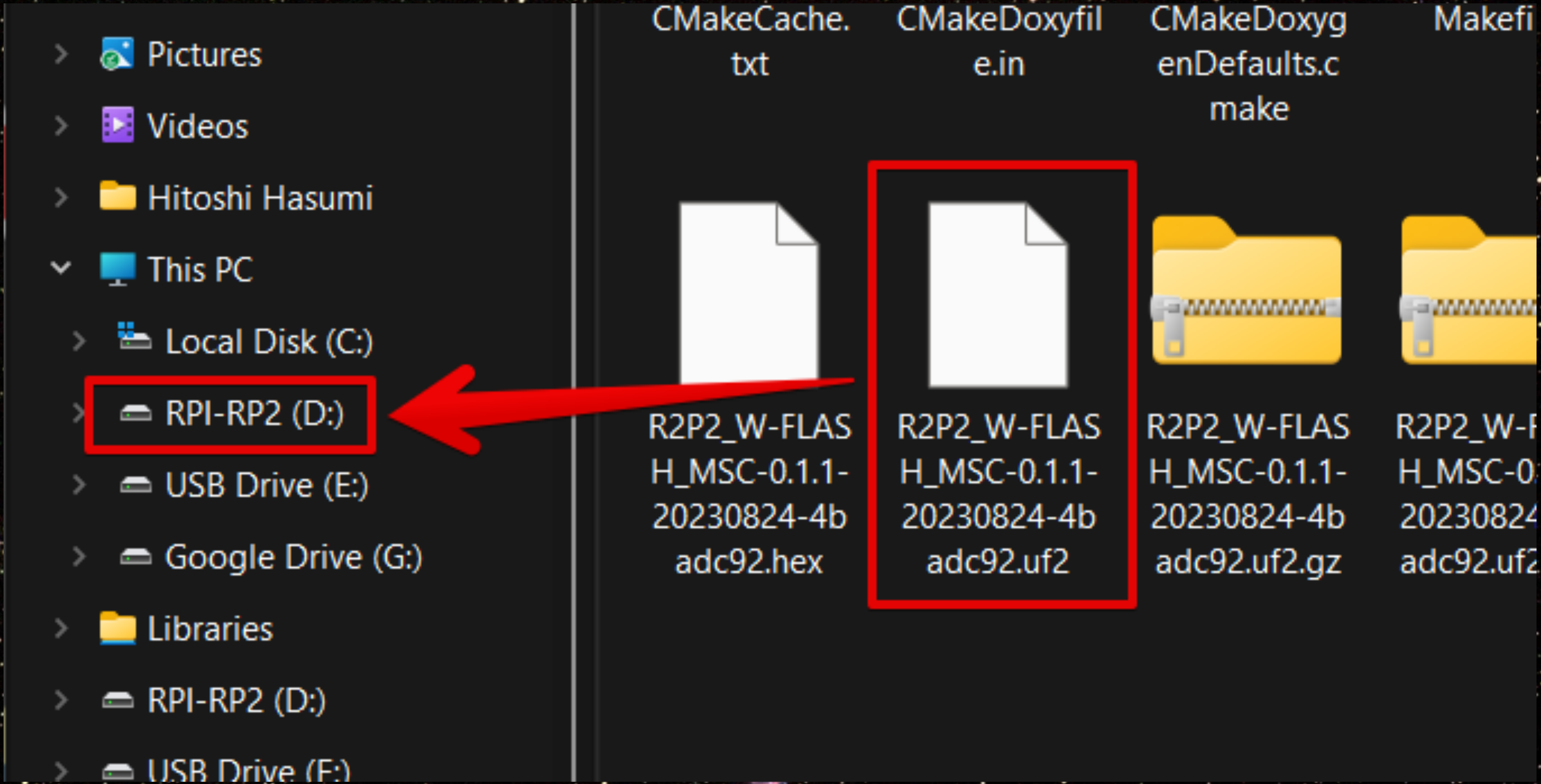
Let's begin 3/5

- Drag & drop `R2P2-*.uf2` into RPI-RP2 drive


Pictures
Videos
Hitoshi Hasumi
This PC
Local Disk (C:)
RPI-RP2 (D:)
USB Drive (E:)
Google Drive (G:)
Libraries
RPI-RP2 (D:)
USB Drive (E:)
CMakeCache.txt
CMakeDoxyfile.in
CMakeDoxygenDefaults.cmake
Makefi
R2P2_W-FLASH_MSC-0.1.1-20230824-4badc92.hex
R2P2_W-FLASH_MSC-0.1.1-20230824-4badc92.uf2
R2P2_W-FLASH_MSC-0.1.1-20230824-4badc92.uf2.gz
R2P2_W-FLASH_MSC-0.1.1-20230824-4badc92.uf2

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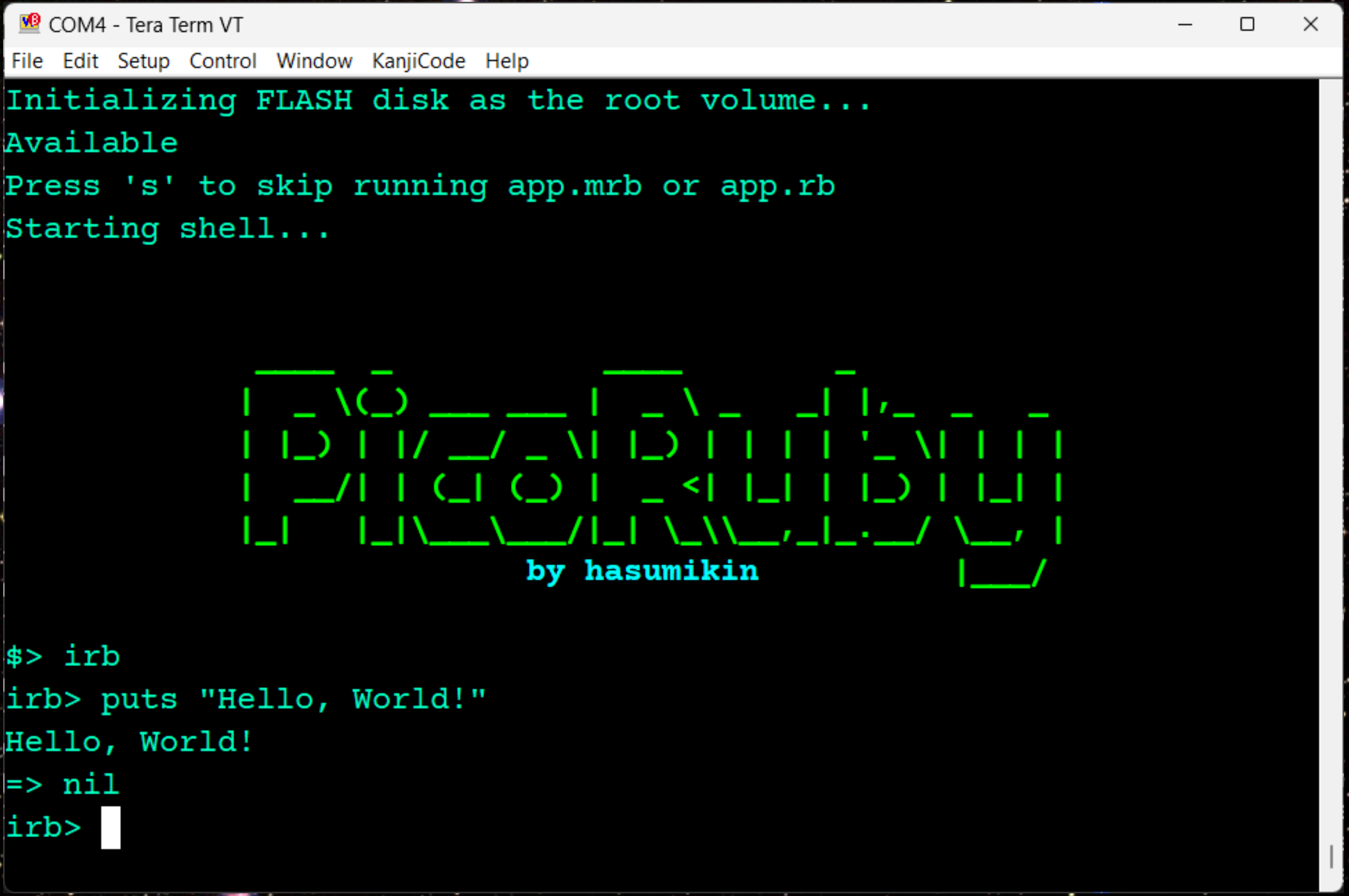
Let's begin 4/5

- Open a proper serial port on terminal emulator



```
Initializing FLASH disk as the root volume...
Available
Press 's' to skip running app.mrb or app.rb
Starting shell...


             ____  _           ____        _
            |  _ \(_) ___ ___ |  _ \ _   _| |__  _   _
            | |_) | |/ __/ _ \| |_) | | | | '_ \| | | |
            |  __/| | (_| (_) |  _ <| |_| | |_) | |_| |
            |_|   |_|\___\___/|_| \_\\__,_|_.__/ \__, |
                           by hasumikin          |___/

$> irb
irb> puts "Hello, World!"
Hello, World!
=> nil
irb>
```

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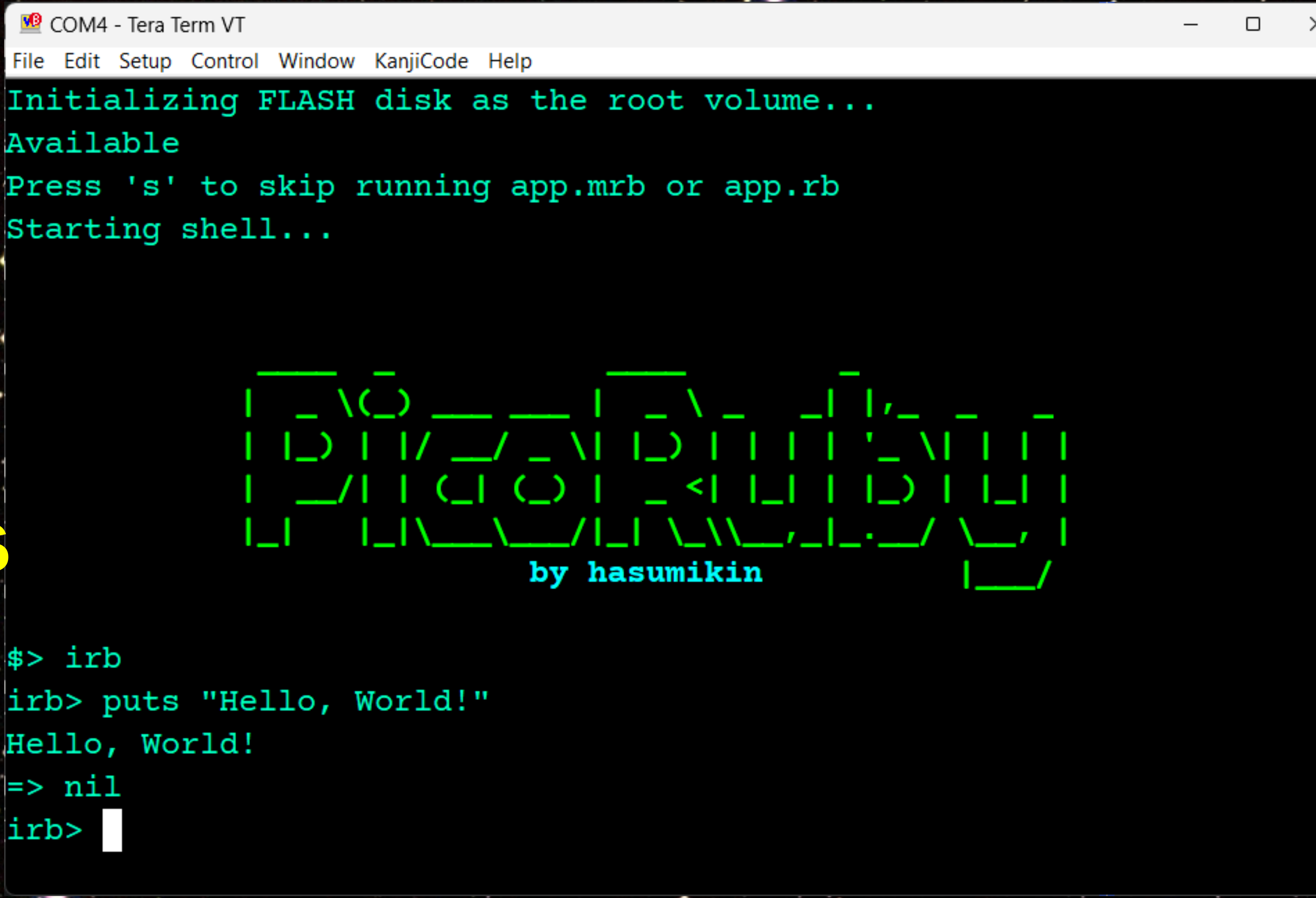
Let's begin 5/5

- R2P2 is a Unix-like shell running on Pi Pico
- You can use some commands like `cd`, `ls`, `mkdir`, and `irb`
- Every computing process is happening on Pi Pico



```
Initializing FLASH disk as the root volume...
Available
Press 's' to skip running app.mrb or app.rb
Starting shell...


     ____  _           ____        _
    |  _ \(_) ___ ___ |  _ \ _   _| |__  _   _
    | |_) | |/ __/ _ \| |_) | | | | '_ \| | | |
    |  __/| | (_| (_) |  _ <| |_| | |_) | |_| |
    |_|   |_|\___\___/|_| \_\\__,_|_.__/ \__, |
                   by hasumikin          |___/

$> irb
irb> puts "Hello, World!"
Hello, World!
=> nil
irb>
```

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By the way, R2P2 stands for

Ruby on
Raspberry
Pi
Pico

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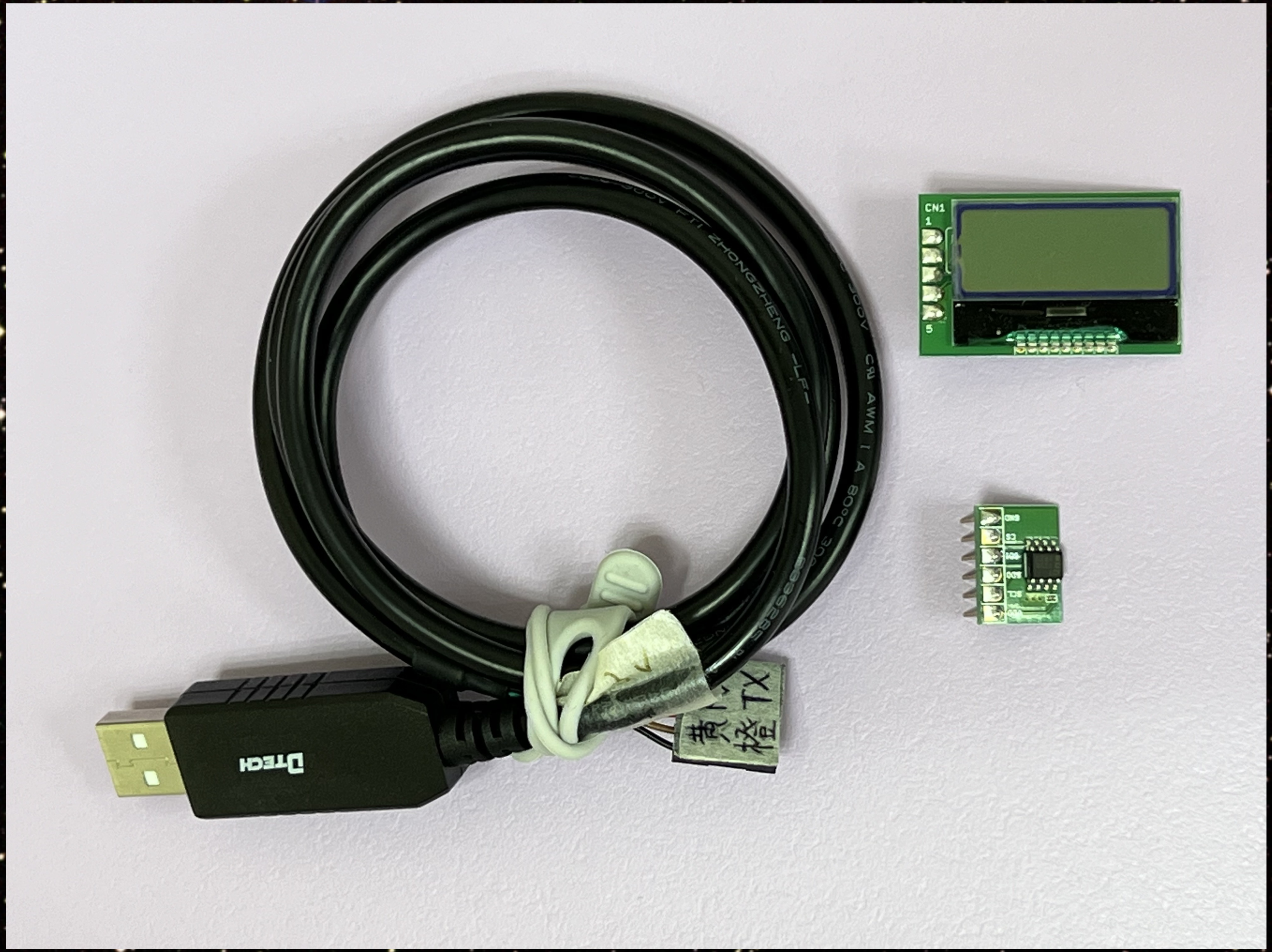
Today's setup

- Raspberry Pi Pico W * 2
- AQM0802 charactor display module
- ADT7310 thermo sensor module
- FTDI USB-TTL serial coverter cable



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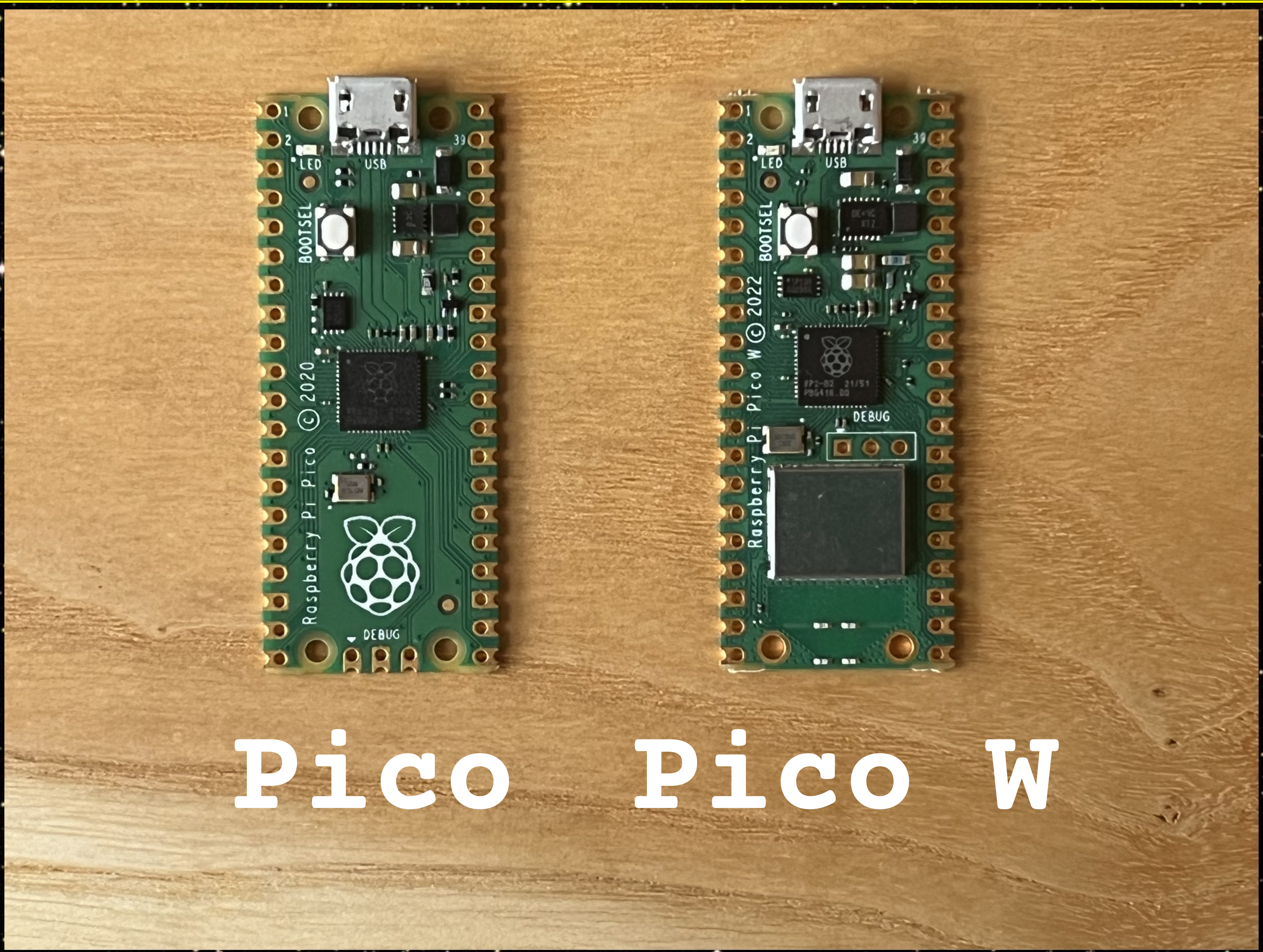
Raspberry Pi "Pico" and "Pico W"



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GPIO

```
irb> gpio = CYW43::GPIO.new(CYW43::GPIO::LEĐ_PIN)
   # gpio = GPIO.new(25, GPIO::OUT) # If Pico w/o W
irb> gpio.write 1   #=> LEĐ turns on
irb> gpio.write 0   #=> LEĐ turns off
irb> 3.times do
irb*   gpio.write 1
irb*   sleep 1
irb*   gpio.write 0
irb*   sleep 1
irb* end            #=> LEĐ blinks three times
```

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LED wraps GPIO

```ruby
# /lib/led.rb in R2P2 drive
require 'gpio'
require 'cyw43'
CYW43.init
class LED
  def initialize
    @gpio = CYW43::GPIO.new(CYW43::GPIO::LED_PIN)
    #     = GPIO.new(25, GPIO::OUT) # If Pico w/o W
  end
  def on
    @gpio.write 1
  end
  def off
    @gpio.write 0
  end
  def invert
    @gpio.read == 1 ? off : on
  end
end
```

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LED wraps GPIO

```
irb> require ’led’
irb> led = LEĐ.new
irb> 3.times do
irb*   led.invert
irb*   sleep 1
irb* end
```

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Peripherals for serial communication

- I2C: To communicate between integrated circuits with support for multiple devices connected to the same bus
- SPI: To facilitate high-speed communication between microcontrollers and peripheral devices
- UART: To establish asynchronous serial communication between devices

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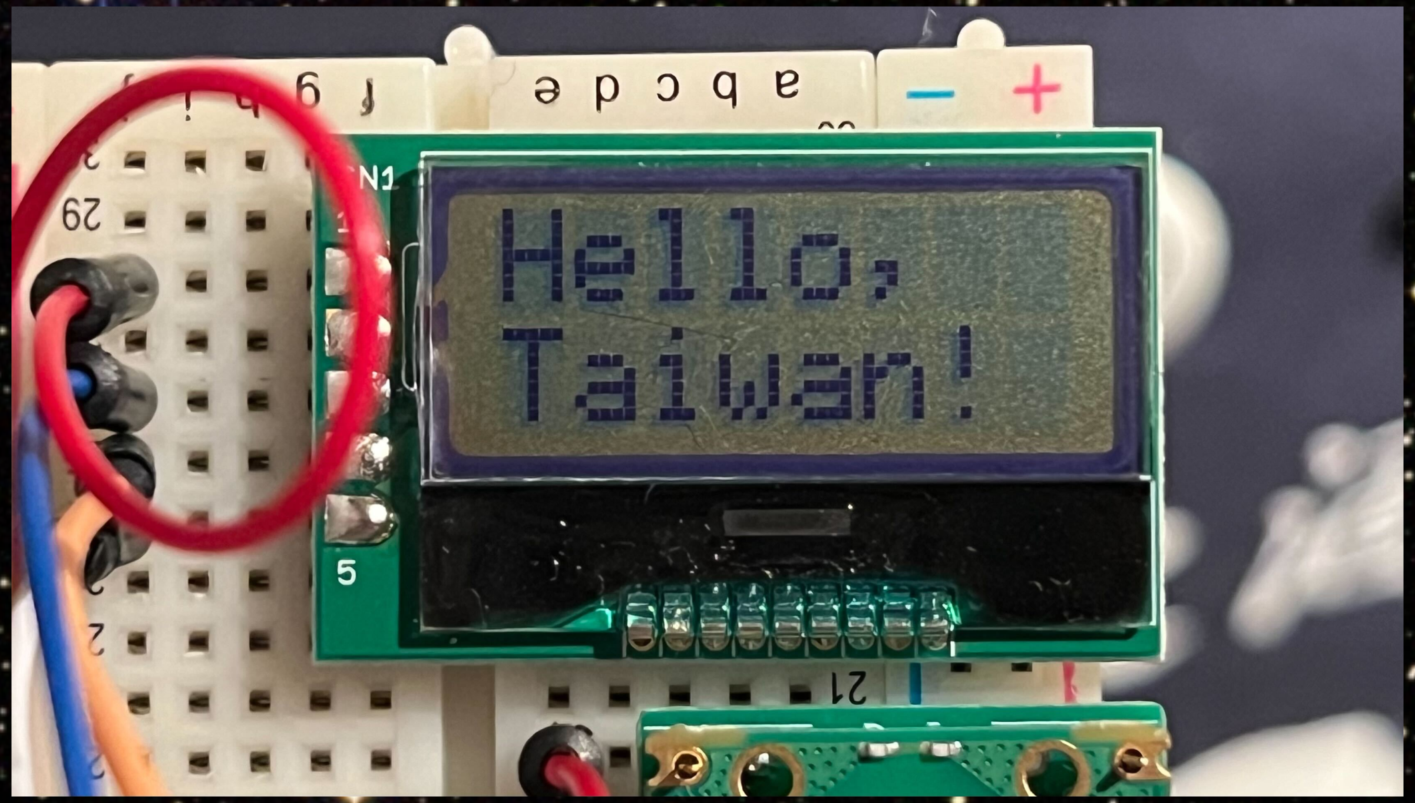
I2C

```
irb> require 'i2c'
irb> i2c = I2C.new(unit: :RP2040_I2C1, sda_pin: 26, scl_pin: 27)
irb> [0x38, 0x39, 0x14, 0x70, 0x56, 0x6c].each { |i| i2c.write(0x3e, 0, i); sleep_ms 1 }
irb> [0x38, 0x0c, 0x01].each { |i| i2c.write(0x3e, 0, i); sleep_ms 1 }
irb> "Hello,".bytes.each { |c| i2c.write(0x3e, 0x40, c); sleep_ms 1 }
irb> i2c.write(0x3e, 0, 0x80|0x40)
irb> "Taiwan!".bytes.each { |c| i2c.write(0x3e, 0x40, c); sleep_ms 1 }
```



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LCD wraps I2C

```ruby
# /lib/lcd.rb in R2P2 drive
require 'i2c'
class LCD
  ADDRESS = 0x3e # 0x7c == (0x3e << 1) + 0 (R/W)
  def initialize(i2c:)
    @i2c = i2c
    reset
  end
  def reset
    [0x38, 0x39, 0x14, 0x70, 0x56, 0x6c].each { |i| @i2c.write(ADDRESS, 0, i) }
    sleep_ms 200
    [0x38, 0x0c, 0x01].each { |i| @i2c.write(ADDRESS, 0, i) }
  end
  def putc(c)
    @i2c.write(ADDRESS, 0x40, c)
    sleep_ms 1
  end
  def print(line)
    line.bytes.each { |c| putc c }
  end
# ...
# See https://github.com/picoruby/picoruby/tree/master/mrbgems/picoruby-ble/example/broadcaster-observer
```

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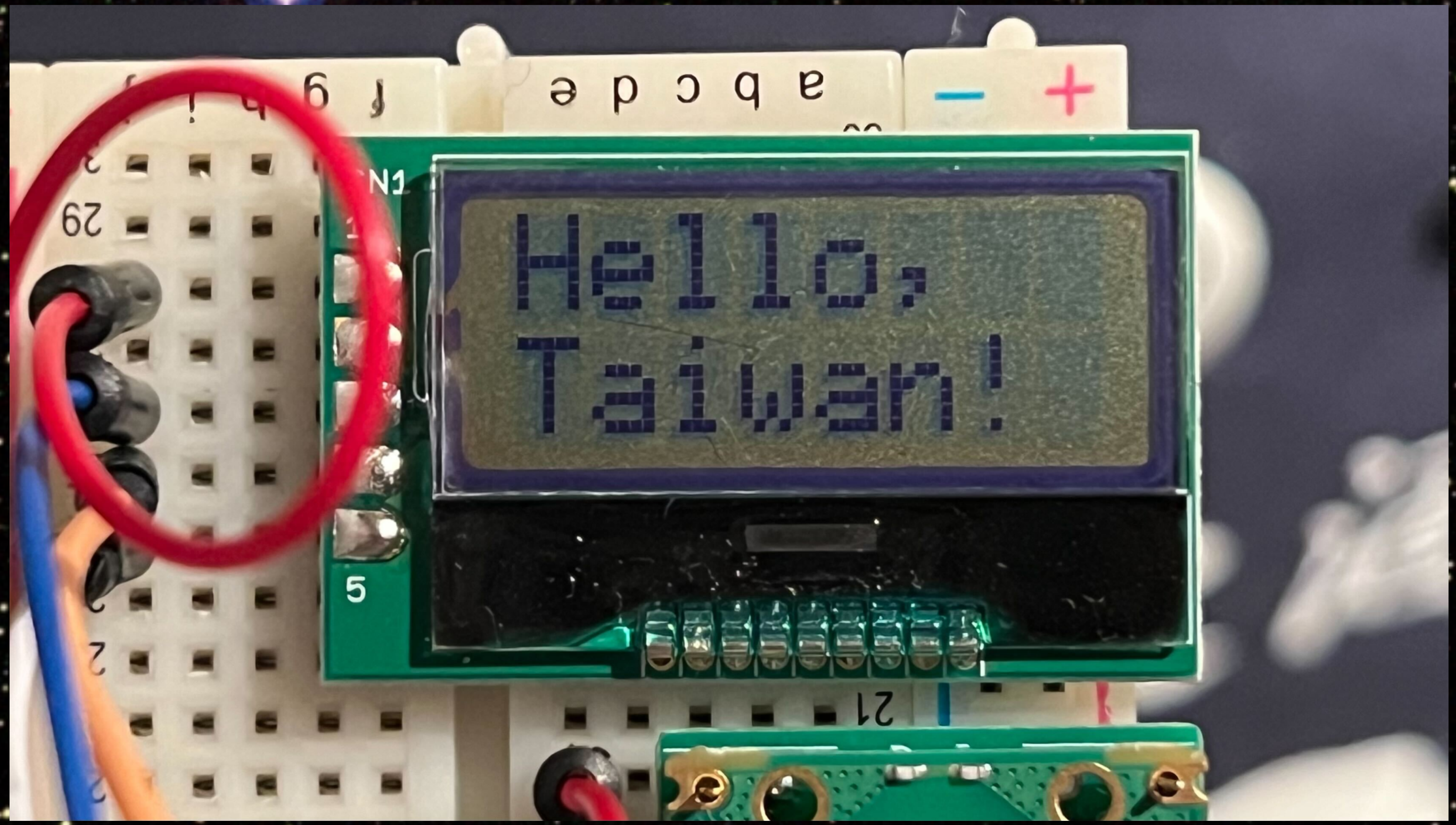
LCD wraps I2C

```
irb> require 'lcd'
irb> lcd = LCD.new(i2c: I2C.new(unit: :RP2040_I2C1, sda_pin: 26, scl_pin: 27))
irb> lcd.print "Hello,"
irb> lcd.break_line
irb> lcd.print "Taiwan!"
```



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SPI

```
irb> require 'spi'
irb> spi = SPI.new(unit: :RP2040_SPI0, cipo_pin: 16,
           cs_pin: 17, sck_pin: 18, copi_pin: 19)
irb> spi.select
irb> spi.write(255,255,255,255) # Reset
irb> spi.write(0x54)            # Start continuous mode
irb> data = spi.read(2).bytes
irb> temp = data[0] << 8 | data[1]
irb> temp / 128.0               # Convert to Celsius
=> 19.5621
```

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THERMO wraps SPI

```ruby
# /lib/thermo.rb in R2P2 drive
require 'spi'
class THERMO
  def initialize(unit:, sck_pin:, cipo_pin:, copi_pin:, cs_pin:)
    @spi = SPI.new(unit: unit, frequency: 500_000, mode: 0, cs_pin: cs_pin,
      sck_pin: sck_pin, cipo_pin: cipo_pin, copi_pin: copi_pin
    )
    @spi.select
    @spi.write 0xFF, 0xFF, 0xFF, 0xFF # Reset
    @spi.write 0x54 # Start continuous mode
    sleep_ms 240
  end

  def read
    data = @spi.read(2).bytes
    temp = (data[0] << 8 | data[1]) >> 3
    # If it minus?
    temp -= 0x2000 if 0 < temp & 0b1_0000_0000_0000
    temp / 16.0  # Convert to Celsius
  end
end
# See https://github.com/picoruby/picoruby/tree/master/mrbgems/picoruby-ble/example/broadcaster-observer
```

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THERMO wraps SPI

```
irb> require 'thermo'
irb> thermo = THERMO.new(unit: :RP2040_SPI0,
              cipo_pin: 16, cs_pin: 17, sck_pin: 18, copi_pin: 19)
irb> thermo.read
=> 19.5621
```

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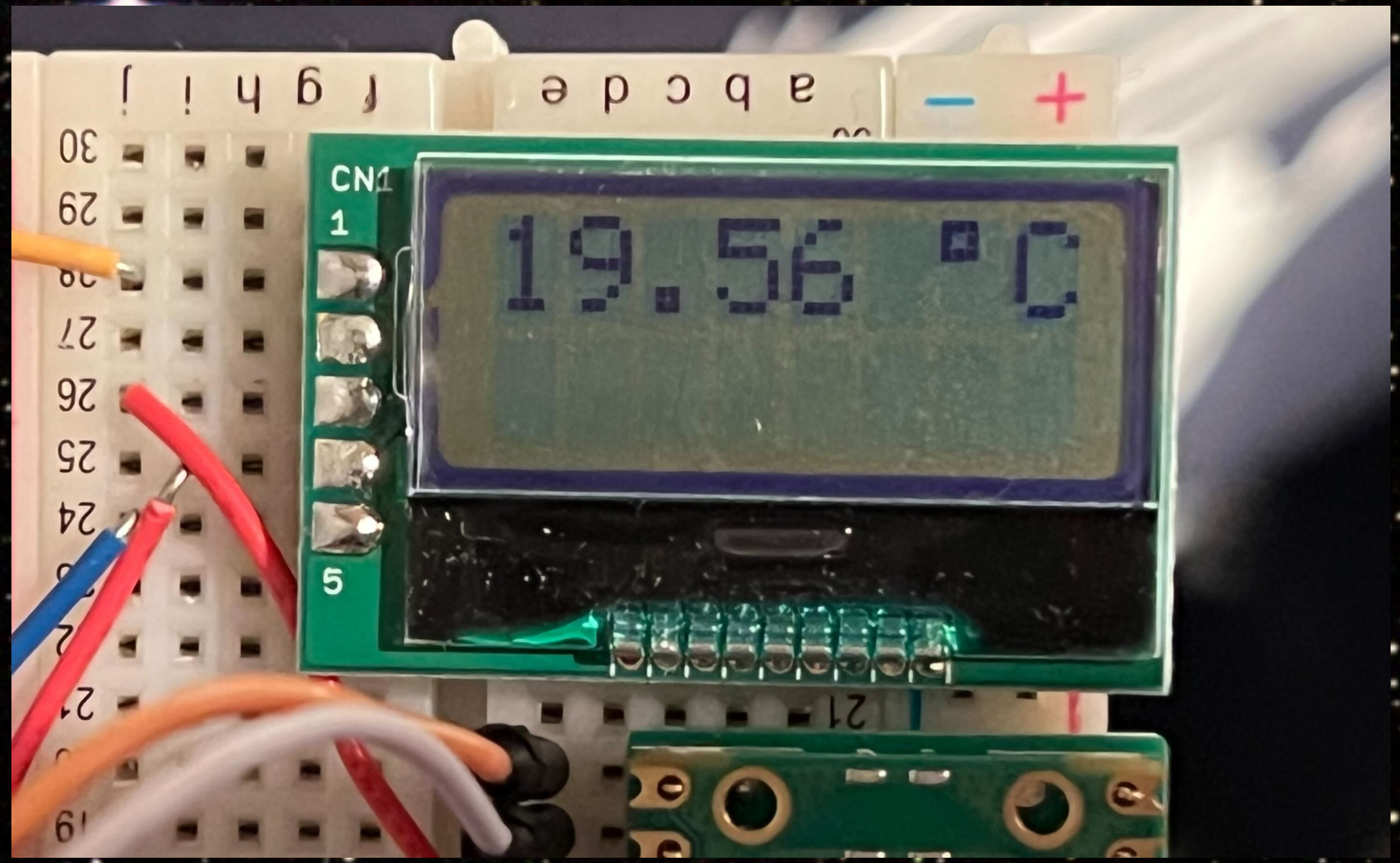
LCD and THERMO

```
irb> require 'lcd'
irb> lcd = LCD.new(i2c: I2C.new(unit: :RP2040_I2C1, sda_pin: 26, scl_pin: 27))
irb> require 'thermo'
irb> thermo = THERMO.new(unit: :RP2040_SPI0,
                cipo_pin: 16, cs_pin: 17, sck_pin: 18, copi_pin: 19)
irb> lcd.print sprintf("%5.2f \xdfC", thermo.read)
```



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UART

```
irb> require 'uart'
irb> uart = UART.new(unit: :RP2040_UART0, txd_pin: 16, rxd_pin: 17, baudrate: 115200)
irb> uart.puts "Hello from Pico!"
=> nil
irb> while true
irb*   if c = uart.read
irb*     uart.write c    # Echo back
irb*     print c
irb*   end
irb* end
Hello to Pico!           # <= "Hello to Pico!" in UART device
```

You don't need to wrap UART. Use as it is

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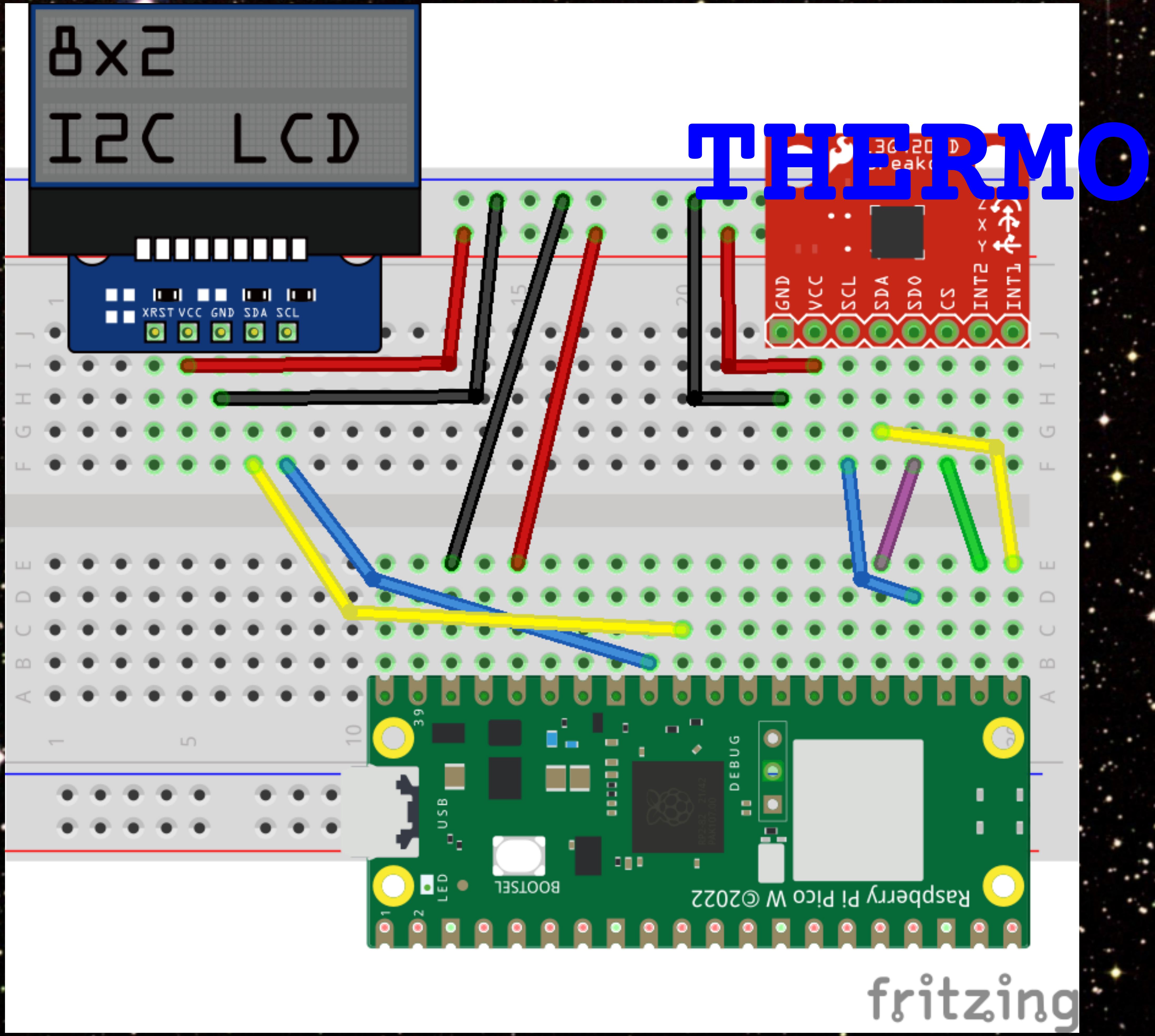
BLE Broadcaster

- Pin assign
  - 3V3 to {LCD,THERMO}:VCC
  - GND to {LCD,THERMO}:GND
  - GPIO16 to THERMO:SDO
  - GPIO17 to THERMO:CS
  - GPIO18 to THERMO:SCL
  - GPIO19 to THERMO:SDI
  - GPIO26 to LCD:SDA
  - GPIO27 to LCD:SCL



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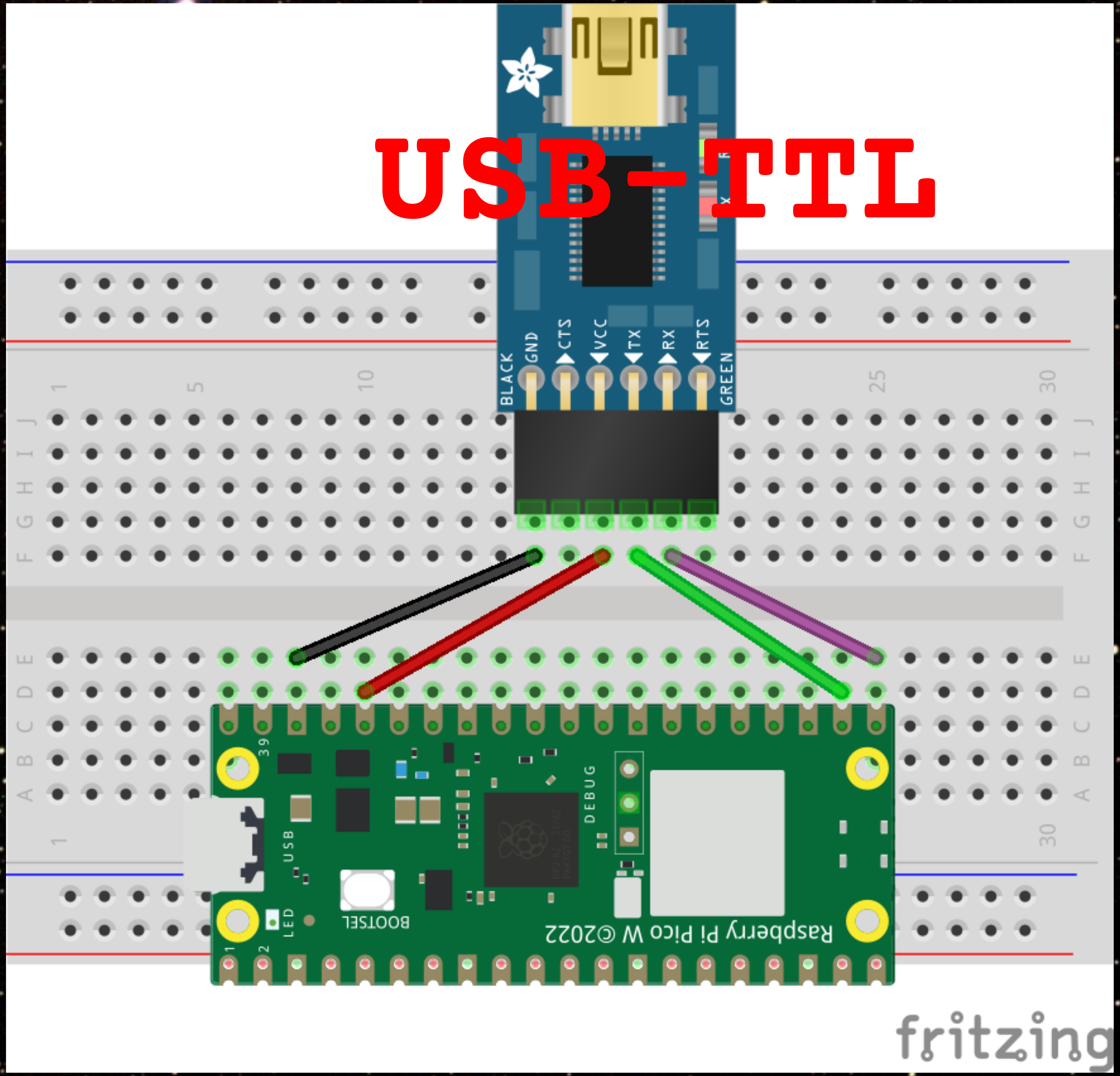
BLE Observer

- Pin assign
  - 3V3 to USB-TTL:VCC
  - GND to USB-TTL:GND
  - GPIO16 to USB-TTL:RX
  - GPIO17 to USB-TTL:TX



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Gems in Broadcaster and Observer

```
# in Broadcaster
$> ls /lib
lcd.rb
thermo.rb

# in Observer
$> ls /lib
led.rb
```

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BLE Broadcaster

```ruby
# /home/app.rb in R2P2 drive
class DemoBroadcaster < BLE::Broadcaster
  def initialize
    super(nil)
    led = CYW43::GPIO.new(CYW43::GPIO::LED_PIN)
    @lcd = LCD.new(i2c: I2C.new(unit: :RP2040_I2C1, sda_pin: 26, scl_pin: 27))
    @thermo = THERMO.new(unit: :RP2040_SPI0, cipo_pin: 16, cs_pin: 17, sck_pin: 18, copi_pin: 19)
    @counter = 0
  end
  def adv_data(send_data)
    BLE::AdvertisingData.build do |adv|
      adv.add(0x01, 0xFF)
      adv.add(0x09, "PicoRuby")
      adv.add(0xFF, send_data)
    end
  end
  def heartbeat_callback
    Machine.using_delay do
      temperature = @thermo.read
      @lcd.clear
      @lcd.print sprintf("%5.2f \xdfC", temperature)
      @lcd.break_line
      @lcd.print "+" * (@counter % 9)
      advertise(adv_data (temperature * 100).to_i.to_s)
    end
    @counter += 1
    Watchdog.update
  end
  def packet_callback(event_packet)
    case event_packet[0]&.ord # event type
    when 0x60 # BTSTACK_EVENT_STATE
      return unless event_packet[2]&.ord ==  BLE::HCI_STATE_WORKING
      @state = :HCI_STATE_WORKING
      Watchdog.enable(2000)
    end
  end
end
DemoBroadcaster.new.start
# See https://github.com/picoruby/picoruby/tree/master/mrbgems/picoruby-ble/example/broadcaster-observer
```

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BLE Observer

```ruby
# /home/app.rb in R2P2 drive
class DemoObserver < BLE::Observer
  def initialize
    super
    @led = LED.new
    @uart = UART.new(unit: :RP2040_UART0, txd_pin: 16, rxd_pin: 17, baudrate: 115200)
    @uart.puts 'Start BLE Observer Demo'
    @last_time_found = Time.now.to_i
    Watchdog.enable(4000)
  end
  def advertising_report_callback(adv_report)
    if adv_report&.reports[:complete_local_name] == 'PicoRuby'
      now = Time.now.to_i
      if 2 < now - @last_time_found
        @uart.puts sprintf("%5.2f degC", adv_report.reports[:manufacturer_specific_data].to_f / 100)
        @last_time_found = now
      end
    end
  end
  def heartbeat_callback
    Watchdog.update
    @led.invert
  end
end
DemoObserver.new.scan(stop_state: :no_stop)
# See https://github.com/picoruby/picoruby/tree/master/mrbgems/picoruby-ble/example/broadcaster-observer
```

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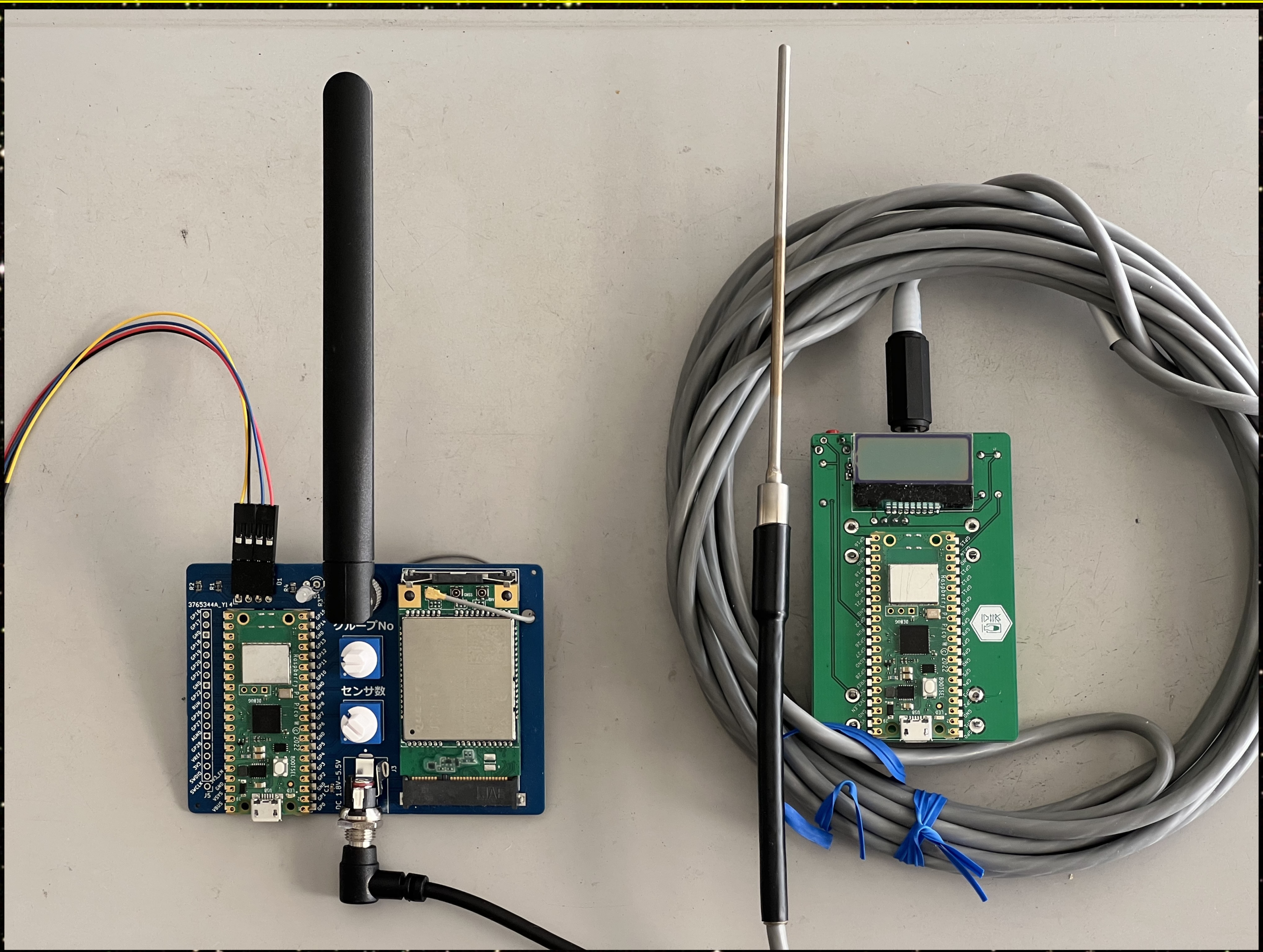
Real world application



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Wrap up

- PicoRuby is a Ruby implementaiton targeting on one-chip microcontroller
- Built-in peripheral gems for general IOs:
  GPIO, I2C, SPI, UART, ADC, and PWM are ready
- You can incrementally write your device drivers and applications with PicoIRB
- BLE gem is also almost ready for real applications

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